ECE661: Homework 7

Fall 2020
Due Date: Oct 19, 2020 (11:59 PM)

Turn in typed solutions via BrightSpace. Additional instructions can be found at BrightSpace.

1 Theory Questions

1. The reading material for Lecture 15 presents three different approaches to characterizing the texture in an image: 1) using the Grayscale Co-Occurrence Matrix (GLCM); 2) with Local Binary Pattern (LBP) histograms; and 3) using a Gabor Filter Family. Explain succinctly the core ideas in each of these three methods for measuring texture in images. (You are not expected to write more than a dozen sentences on each).

2. With regard to representing color in images, answer Right or Wrong for the following questions:

   (a) RGB and HSI are just linear variants of each other.

   (b) The color space L*a*b* is a nonlinear model of color perception.

   (c) Measuring the true color of the surface of an object is made difficult by the spectral composition of the illumination.

2 Introduction

The goal in this homework is to implement a very simple image classification algorithm using Local Binary Pattern (LBP) features and Nearest Neighbor (NN) classifier. You are provided with two sets of images one for training and the other for testing. The images in the database belong to five different classes – building facades, trees, mountainous ranges, cars, and beaches. The first step is to extract feature vectors from all the images. You will implement your own Local Binary Pattern (LBP) feature extraction procedure as discussed in class and obtain a feature vector for each of the images in the training and testing datasets. Then use NN classifier to assign labels to the testing images by comparing feature vectors of testing images with feature vectors of training images.

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(a) building (b) Car (c) Mountain (d) Tree (e) Beach

Figure 1: Sample input images.

3 Programming Tasks

The programming tasks for this homework are outlined in the following subsections.

3.1 Understanding the dataset

- You are provided with a dataset containing 5 types of images building facades, trees, mountainous ranges, cars, and beaches. There are 20 training images and 5 testing images for each class. One sample image from each class is shown in Figure 1.
- The given dataset contains two subfolders called 'training' and 'testing'. Inside the 'training' folder, there are five subfolders belonging to each of the five classes of images. Each training subfolder contains 20 training images. The images inside 'testing' folder are named as follows: <class of image> <image number>.jpg. Note that there are 5 images for each class in the 'testing' folder.

3.2 LBP Feature Extraction

Implement **your own LBP feature extraction** algorithm to obtain a histogram feature vector for each image in the database. You can refer to Prof. Avi Kak's implementation [1].

3.3 NN-Classifier

- Using Euclidean distance metric find the k-nearest neighbors of the feature vector of each testing image in the feature space of training images. As a result you will obtain k possible labels to associate with the testing image. You can empirically set $k = 5$.
- To choose which label – out of the k labels – to assign to the testing image, you need to find the label which appears maximum number of times in the set of k labels.

3.4 Performance Measures

- Construct a confusion matrix based on your classification results. Your confusion matrix will be a 5×5 matrix since there are 5 classes. Rows correspond to the actual class labels while columns correspond to the predicted class labels. Note that a perfect confusion matrix will be a diagonal matrix with all diagonal values equal to 5. For more information on confusion matrix refer to [2].
- Calculate the overall accuracy of your algorithm.

4 Submission Instructions

Include a typed report explaining how did you solve the given programming tasks.

1. Turn in a zipped file, it should include (a) a typed self-contained pdf report with source code and results and (b) source code files (.py, .cpp,.c). Rename your .zip file as hw7_<First Name><Last Name>.zip and follow the same file naming convention for your pdf report too.
2. Your pdf must include a description of
   - Your answer to the theoretical questions in Sec. 1
   - A clear description of your implementation for each of the given subtasks.
   - LBP histogram feature vector for at least one image from each class.
   - Your output confusion matrix with your observations on the overall accuracy.

- Your source code. Make sure that your source code files are adequately commented and cleaned up.

References

[1] Texture and Color Tutorial. URL https://engineering.purdue.edu/kak/Tutorials/TextureAndColor.pdf.

[2] Confusion Matrix. URL https://en.wikipedia.org/wiki/Confusion_matrix.